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RESEARCH ARTICLE



# A human capability approach to transformative innovation policy. Theoretical insights and practical implications for directionality

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## ABSTRACT






Transformative Innovation Policy (TIP) is an emerging approach to science, technology, and innovation policy that addresses social and environmental challenges. While TIP literature highlights the importance of considering multiple innovation pathways, it often overlooks the injustices hindering them. This paper explores how the Capability Approach (CA) can enhance the analysis and practical considerations of directionality within the TIP. We begin by discussing the TIP's directionality principle, adopting a more politically nuanced view that sees innovation as *irreducible pluralities of possibility in balanced ways* ([Stirling, A. 2024. "Responsibility and the hidden politics of directionality: opening up 'innovation democracies' for sustainability transformations." *Journal of Responsible Innovation* 11 (1): 2370082.]). Based on this conception of directionality, we propose rethinking TIP principles, emphasizing the democratic aspect of innovation and, to this end, introducing a new principle: democratic decision-making. We argue that strengthening democracy is vital for continuously refining and improving collective decision-making processes locally and globally, making it an essential feature for TIP and innovation policy in general. Furthermore, we examine the core elements of the CA – capability, agency, and conversion factors – and demonstrate how these can inform TIP by adding justice considerations to its core framework. This potential is illustrated through a case study, showing how the CA can guide specific considerations in TIP policy engagements. Finally, we conclude by discussing the mutual benefits: how TIP's directionality can be enriched by the CA, and conversely, how the CA can be enhanced with the new understanding of TIP directionality.

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## Introduction

Transformative Innovation Policy<sup>1</sup> (TIP) is a novel approach to shaping and implementing science, technology and innovation (STI) policy (Schot and Steinmueller 2018; Weber and Rohracher 2012). It recognizes the importance of addressing societal needs and pursuing sustainable, inclusive, and equitable development. The TIP framework emphasizes the need to foster systemic change through innovation policies encompassing social development and environmental sustainability. The processes of designing, implementing, and evaluating TIP are as important as the outputs. Hence, the approach emphasizes participatory and democratic engagements throughout the policy cycle (agenda setting, formation, adaptation, implementation, evaluation) (Frisch Aviram, Cohen, and Beeri 2020), involving diverse actors, not just policymakers. TIP acknowledges that conventional STI policies often focus on promoting technological advancements without sufficiently considering broader social and environmental dimensions. While technological innovation is undoubtedly crucial, TIP recognizes that sustainable development requires a more systemic, holistic and inclusive approach (Diercks, Larsen, and Steward 2019; Schot and Steinmueller 2018).

However, despite its emphasis on directionality towards social and environmental sustainability, we argue that TIP has not sufficiently discussed and developed its justice dimension. Issues such as equity in accessing innovation benefits (Papaioannou 2024; Ziegler 2015), a more profound concern about barriers to participating in innovation processes (Papaioannou 2014), power imbalances (Avelino and Rotmans 2009) and epistemic injustices (Zwart, Barbosa Mendes, and Blok 2024) should be considered thoroughly in TIP (Boni, Velasco, and Tau 2021). This paper proposes using the capability approach (CA) (Alkire and Deneulin 2009; Robeyns 2005, 2017; Sen 1999) to assess the directionality of TIP. While the CA is not a theory of social justice<sup>2</sup>, it offers substantial considerations that can enhance the analysis of the directionality of innovation policy, particularly within the TIP framework. By broadening the understanding of what sustainable, inclusive, and equitable development entails, the CA provides elements for considering how innovation policy can contribute to these goals (Capriati 2022; Chiappero-Martinetti, Houghton Budd, and Ziegler 2017; Ziegler, Karanja, and Dietsche 2013).

According to Sen (2009), the CA evaluates freedom based on two dimensions: opportunity and process. Both dimensions emphasize the importance of exercising political freedom and expanding public capabilities, which are central to Sen's theory of justice (Tully 2013). Public participation provides victims of injustice with a platform to express their concerns and address specific wrongs. Sen argues that this is a crucial element of value democracy, where public reasoning is vital in shaping democratic decision-making processes.

The opportunity aspect of freedom concerns our ability to achieve what we value (our capabilities). In contrast, the process aspect of freedom examines the process of choice related to agency (Sen 2009, 228). An agent is *'someone who acts and brings about change, and whose achievements can be judged in terms of her own values and objectives'* (Sen 1999, 19). In this sense, agency is related to taking an active role in a community's well-being (Olsaretti 2005). Finally, the CA introduces the concept of conversion factors, which are the personal traits, social arrangements, and environmental conditions that determine an individual's ability to convert resources into capabilities (Robeyns 2005, 2017).

Using the opportunity and process aspect of freedom, the idea of agency, and the concept of conversion factors to examine directionality, our paper poses the following

research question: How can the CA enhance the analysis and practical considerations of directionality within the TIP? To explore this question we pose three subsidiary questions, To what extent can the opportunity and process aspects of freedom scrutinize the directionality of TIP? How can agency contribute to enhancing the process perspective of TIP? And finally, how can the conversion factors be incorporated into the analysis of how TIP enables the kinds of lives people have reasons to value? To accomplish this, we will examine a particular approach to TIP developed by the Transformative Innovation Policy Consortium (TIPC<sup>3</sup>), which outlines six principles for formulating innovation policies with transformative potential. Among these principles, directionality stands out as a key concept. We will critically examine the six principles through the lens of a comprehensive approach to directionality in innovation as *grasping irreducible pluralities of possibility in balanced ways*, as proposed by (Stirling 2024, 14). We argue that a redefinition of directionality is necessary to reflect on the justice dimension of TIP, aligning with the propositions of the CA.

The structure of the paper is the following: Section 2 describes the particular approach to TIP developed by the TIPC and how this approach has been implemented in practice through six principles: directionality, system-level impact, societal goal, learning and reflexivity, conflict and consensus and inclusivity. Section 3 proposes a new interpretation of the principles, more attuned to the idea of directionality as grasping multiplicities of plural ends. Section 4 briefly presents the main elements of the CA used in our analysis and how other capability scholars have understood the relationship between innovation policy and the CA. Then, we undergo a Capabilitarian analysis of the new principles of TIP developed in Section 3 using the CA concepts. Section 5 provides an example of how a TIP policy engagement could be enriched using the new principles. Section 6 concludes with some final reflections on the new understanding of directionality informed by the CA.

## Six principles to define TIP

Schot, Kivimaa, and Torrens (2019) contend that addressing complex challenges requires an approach to innovation policy that embraces uncertainty and complexity by fostering experimentation, which in turn informs and facilitates learning processes and drives change in individuals, organizations, and institutions. This type of policy focuses on changing unsustainable dominant practices in socio-technical systems that provide basic needs such as energy, mobility, and food. Socio-technical systems are understood through a multidimensional approach including how knowledge is produced through science and technology (i.e. power plants and distribution grids technologies in the energy system), the policies and governance arrangements embedded in regulations and sanctions (i.e. agricultural subsidies or land-use regulation in the food system), market practices and users preferences (i.e. family vehicle design with strong emphasis on safety in the mobility system), industry standards and protocols (i.e. operation of large power plants producing constant supply of energy with national standards in the energy system), and the cultural setting (i.e. celebration of car-enabled freedom in the mobility system). Transformation in this approach is based on the Multi-Level Perspective framework of sustainability transitions theory (Geels 2002; Rip and Kemp 1998; Schot and Geels 2007), which

identifies three levels of interaction: landscape, regime, and niche. Niches are protective spaces where transformative ideas and practices can develop and evolve, presenting alternatives and putting pressure on the dominant and aligned practices and routines in the system or regime. System transitions may occur when the regime is destabilized by external trends in the landscape, creating windows of opportunity for innovations developed in the niches to influence or replace the regime. To foster sustainability transitions, the TIPC proposes six principles for designing policy with transformative potential (Schepers and Steinmueller 2019; Schot, Kivimaa, and Torrens 2019, 23–24), including:

- 1) Focus on directionality: Technological solutions that are offered to address social and environmental problems are not neutral. A variety of technological choices and alternative innovation pathways need to be considered for transformative innovation.
- 2) Societal goal: TIP should be directed to address grand social challenges, such as the provision of food, energy, health, biodiversity, and impacts of climate change, in line with the SDGs.
- 3) Systems-level impact: TIP should be directed to change underlying routines, values, and norms that guide the use and application of technologies in society, keeping with the view that transformational impact is in alignment with new routines across several dimensions of a socio-technical system (culture, governance, industry, market, science, and technology.)
- 4) Learning and reflexivity: A transformative policy initiative should facilitate the exchange of accumulated knowledge and continuous reflections on existing routines, understanding each other's assumptions and worldviews (second-order learning), with a view of changing mindsets and assumptions embedded in dominant practices.
- 5) Conflict vs. consensus: TIP must recognize conflicts arising from diverse interests and views. Conflicts and a search for common ground that allows consent should be integral to the process.
- 6) Inclusiveness: TIP should ensure both breadth of participation and empowerment of actors excluded from policy processes, such as civil society, users, and marginalized communities, as well as the depth of involvement – the extent to which included actors can influence the processes of the policy cycle.

The principles emerged from collaborative efforts among TIPC members during the first year and were shaped by their collective experiences in various experimental policy engagements in Mexico, Colombia, Finland, Sweden, and South Africa (Schot et al. 2017). In the following years, the six principles have been key elements of training sessions with different government partners of TIPC<sup>4</sup> and other stakeholders using materials and tools on the consortium website. More recently, a group of researchers working in the Latin-American and Caribbean Hub of Transformative Innovation Policy (one of the TIPC Hubs) developed the policy radar tool.<sup>5</sup> Each of the six principles includes questions to be asked to the participants in engagements; at the end, each principle is rated, and the results are presented graphically as a radar. A methodological account of how the policy radar has been applied in an experiment in Colombia is described in (Marin-Montoya 2023).

## Revisiting the TIPC principles

### *Directionality as a guiding principle*

While the existing principles offer practical guidance, they remain underdeveloped in academic literature. Therefore, we critically examine these principles, contending that directionality is the overarching principle guiding the others. We adopt the interpretation of directionality presented as *grasping irreducible pluralities of possibility in balanced ways*. This interpretation of directionality is different from 1) *directing innovation* (driving and accelerating processes of adoption and acceptance) and 2) ‘the *direction of innovation*’ (steering selected particular possible pathways rather than others) (Stirling 2024, 14).

We argue that within the TIPC, as currently conceived, directionality aligns more with the second interpretation – steering particular pathways. While this may not have been the initial intent, the principles as they have been developed and applied in practice tend to address isolated sets of questions without adequately linking them back to the broader issue of directionality. However, by adopting Stirling’s interpretation of directionality (as also discussed in (Arora and Stirling 2020; Stirling 2009)), we contend that directionality could fundamentally impact the sustainability and justice outcomes of innovation processes. Given the complexity and politicized nature of sustainability and justice, innovation could take many forms and directions, making it crucial to move beyond simply ‘directing’ innovation or defining a single ‘direction.’

Instead, we advocate for ‘embracing directionality’ as a core principle of innovation governance. As a holistic approach, directionality encourages the exploration of diverse alternatives rather than adhering to predetermined or singular pathways imposed by specific groups within defined contexts. Shaping and assessing the directionality of change involves critically evaluating different innovation possibilities and acknowledging that no innovation is neutral – each choice carries its own risks and opportunities (Schippel and Truffer 2020). Embracing a multiplicity of pathways also entails dismantling entrenched privileges within actor and knowledge networks, ensuring that a broader range of perspectives and understandings are included in the innovation process (Edler and Boon 2018).

### *Democratic decision-making as a new principle*

This new interpretation of directionality necessitates a re-examination of the other five principles. We propose retaining the original definitions of three key principles – societal goal, system impact, and learning and reflexivity – while strongly linking them to this revised understanding of directionality. Additionally, we suggest consolidating the principles of conflict versus consensus and inclusivity into a single, more robust principle, termed democratic decision-making (new 4th principle). The following sections will first outline the connections between the first three principles and a responsible vision for innovation policy. We will then underscore the significance of emphasizing and reinforcing the democratic dimension within Transformative Innovation Policy (TIP).

Research and innovation oriented towards societal goals (new principle #1) is at the core of TIP (Haddad and Bergek 2023). Addressing common challenges requires incorporating ethical, social, and environmental considerations into assessing new

technologies and recognizing their non-neutrality. This principle is also strongly related to democratic decision-making because prioritizing societal and ecological well-being entails the implementation of policies that emphasize accountability and representation, ensuring the inclusion of both direct and indirect stakeholders in issue identification and decision-making processes, which is essential for fostering a just transition (Köhler et al. 2019; van Est 2017). It also broadens the analysis to mitigate disconnections between enabling innovation endeavors to tackle societal challenges while pre-emptively considering potential adverse effects, such as those outlined in challenge-driven initiatives. For instance, upfront recognition of tensions and trade-offs, such as those between speed, competitiveness, and societal responsibility in sectors like the UK's industrial biotechnology industry, as discussed by Rosemann and Molyneux-Hodgson (2023), is crucial.

The (new) second principle, system-level focus, provides both the approach to complexity and the change ambition of TIP. Embracing a systemic perspective on intricate social and ecological challenges enables us to transcend mere market mechanisms, such as the traditional demand-supply dynamics or production-consumption paradigms. Moreover, it propels beyond debates centered solely on economic alternatives, be it growth, degrowth, or post-growth models, as well as simplistic technological solutions. Through a comprehensive understanding of societal needs within socio-technical systems, which encompass the intricate interplay of science and technology, markets and users, industry and finance, policy and governance, and cultural dimensions, TIP delves deeper into the configuration of underlying rules embedded in routines, beliefs, and values that shape the behavior of diverse actors. This holistic approach ensures that the focus remains on facilitating change by nurturing alternative pathways developed by non-dominant actors rather than merely optimizing the current manifestations of existing systems (Geels and Schot 2007; Ghosh et al. 2022).

The (new) third principle, learning and reflexivity, is paramount in how TIPC understands TIP. For an innovation policy to truly foster transformative change, it must challenge established mental frameworks, bodies of knowledge, routines, beliefs, and practices across diverse stakeholder groups. This underscores the critical importance of adopting a formative approach to the design, implementation and monitoring of policy. Such an approach necessitates continuous learning and reflexivity, which can only be achieved through the inclusive co-creation of knowledge. This process involves finding solutions to specific problems and persistently questioning assumptions and perceptions associated with dominant interpretations and worldviews, opening the policy space for a diversity of possibilities (Ghosh et al. 2021; Molas-Gallart et al. 2021). Expanding on this principle and connecting it with the democratic decision-making principle, we agree with Zwart, Barbosa Mendes, and Blok (2024) that it is necessary to encourage epistemic diversity by valuing and incorporating various forms of knowledge. This encompasses scientific and technological expertise and indigenous, local, and marginalized perspectives, which are often underrepresented yet crucial in guiding innovations. As they express it, 'we have to radically broaden our epistemological scope and methodological repertoire. And this includes the ability to address antagonism and genuine epistemic difference and divergence.' (Zwart, Barbosa Mendes, and Blok 2024, 3). Moreover, it acknowledges the multitude of approaches available for resolving conflicts among 'institutionally diverse actors' (Pel, Raven, and van Est 2020). Hence, a practical way to apply this principle is by promoting policy experimentation and formative evaluation

throughout the entire policy cycle by reflecting upfront about responsibility, representation, issue identification, and orientation as developed in Responsible Research and Innovation (RRI) (van Est 2017). By encouraging such practices, policy initiatives can remain flexible and adaptive while simultaneously fostering a learning environment for all stakeholders involved. This iterative approach ensures that policies evolve with emerging challenges and insights, thereby enhancing effectiveness and impact.

Concerning the discussion on the new fourth principle, both conflict and consensus and inclusivity have sparked debates among sustainability transitions and RRI scholars (Avelino et al. 2016; Kalt 2024; Pel et al. 2023). The notion of sustainability is highly contested, so different actors and social groups tend to disagree about the most advisable innovations and paths towards transitions. Since transitions can threaten the economic positions and business models of some of the most powerful industries (oil, automotive, electrical, food), these historical actors (incumbents) want to protect their vested interests and challenge the necessity and urgency of transitions (Köhler et al. 2019). More specifically, the debates on what justice is in transitions have highlighted the importance of procedural justice to address decision-making processes, distribution of power among stakeholders, and methods for conducting and evaluating decision-making (Coulson and Milbourne 2021; Loo 2014; Whitfield et al. 2021). As an example, in the food system, marginalized individuals, communities, or nations are frequently disregarded in decision-making processes during transitions in the food system (Biermann et al. 2012; Glennie and Alkon 2018). Participation is a crucial element of procedural justice; however, due to unequal power dynamics, mere participation does not ensure that stakeholders can voice their concerns or influence procedural outcomes (Turnhout et al. 2020). We argue that alluding to democratic processes is a way to enhance the importance of cultivating and empowering alternative innovation practices developed by non-dominant actors, thereby bolstering their agency to experiment and challenge unfair and unsustainable dominant practices (Avelino, Monticelli, and Wittmayer 2019). Deepening democracy serves as a mechanism for continually reflecting and improving collective decision-making processes locally and globally. It fosters social transformative innovation by nurturing civil society, promoting co-governance, creating spaces for enhanced autonomy and self-management, and improving the quality of deliberation processes (Boni, Belda-Miquel, and Velasco 2023).

## **Examining the directionality of the TIP principles from the capability approach**

This section discusses how the CA can enhance the directionality analysis of TIP. We answer this question by defining the core elements of the CA we use in our analysis and how capability scholars use them to analyze innovation processes and outcomes. Then, we present our interpretation of the TIP principles informed by the CA.

### ***The CA and innovation***

As outlined in the introduction, Sen (2009) distinguishes between two crucial dimensions of freedom: opportunity and process. The opportunity aspect, which relates directly to the capability space, forms the foundational principle of the CA. This principle



emphasizes that when we pose normative questions, our focus should be on what individuals are able to do and the kinds of lives they are able to lead (Robeyns 2017, 7). This perspective shifts the emphasis from mere resource availability to the actual freedoms individuals have to pursue their valued goals. In the context of innovation studies, Capriati (2013) emphasizes the critical role of the learning capability in the innovation process, aligning it with Nussbaum's (1999) identification of learning as one of the core human capabilities. This underscores the idea that fostering the ability to learn is central to personal development and crucial for driving innovation and adapting to new challenges. Reframing what Lundvall (2007) proposes, Capriati (2013, 8) argues that learning enhances the ability of individuals and groups to interact with and thrive in their environment, directly contributing to human well-being. We concur with Capriati, emphasizing second-order learning, which implies changes in beliefs, values, behaviors, and assumptions in understanding social and environmental problems and solutions (Schot, Kivimaa, and Torrens 2019). We will return to this point in the next section when discussing the proposed principles of TIP.

Another relevant study exploring the link between the CA and innovation is described in Belda-Miquel, Pellicer-Sifres, and Boni (2020). The authors analyzed energy cooperatives and food purchasing groups as examples of grassroots innovations. These are examples of how citizens have the potential to contribute to – or even lead – the transition to more sustainable and just societies by transforming patterns of everyday production, exchange, and consumption of goods and services (Hossain 2016; Smith et al. 2015). Belda-Miquel, Pellicer-Sifres, and Boni (2020) argue that these kinds of innovations contribute to multi-dimensional human flourishing (and to the flourishing of relations between humans and non-humans); they improve public reasoning processes by creating counter-narratives, democratic spaces, and new capabilities for reasoning and mobilization; and they create better structural conditions for human flourishing for all through the creation of more diversified, decentralized, and democratic systems.

This analysis relates to the idea of freedom as a process presented by Sen (2009) and how the process dimension of innovation should expand people's capabilities. Mazigo (2017) highlights the importance of using participatory methodologies to involve marginalized communities in processes leading to social innovation. In his research on the fishing sector in Tanzania, he noticed that action research methodologies helped to reflect on individual and collective challenges and to propose novel ideas, strategies, services, and products. Moreover, using these methodologies, communities experienced a change in their perception of social status, which is an important aspect contributing to their aspirations and capabilities. Here, we see how participatory methodologies can empower a person's or community's capacity to act, make meaningful choices, pursue goals that ultimately enhance well-being, and contribute to personal fulfillment (Olsaretti 2005).

Another contribution is presented by Ibrahim (2017), who notes that by engaging in collective actions, vulnerable people experiencing poverty can enhance their agency and create new collective capabilities that each individual alone could not achieve. While the primary focus of this paper lies beyond the scope of delving into the debate on whether capabilities can be confined solely to individuals or extended to collectives,<sup>6</sup> it remains intriguing to observe the author's emphasis on participatory methodologies and critical thinking. These methodologies foster a collective vision, enabling effective collaboration

with the state, civil society, and donors in the pursuit of challenging prevailing power relations.

Besides examining capabilities and processes, conversion factors are critical to analyze innovation processes. Conversion factors relate to the factors that determine the extent to which an individual can exercise their capabilities. They include personal characteristics such as health or education, social influences such as cultural norms or social policies, and environmental conditions such as infrastructure or climate. Conversion factors play a crucial role in understanding the inequalities in people's ability to achieve well-being by converting resources into valuable functionings (Robeyns 2005, 2017). Both agency and conversion factors have not been sufficiently explored in innovation, with a few exceptions. Bajmócy and Gébert (2014, 99) analyze innovation policy using elements of the CA and Oosterlaken (2012) stresses the relevance of individual, social, and environmental conversion factors that influence how people may achieve different valuable functionings through new technologies. This process occurs in complex and dynamic ways, modeled by existing structures that limit but also present opportunities for change (Belda-Miquel, Pellicer-Sifres, and Boni 2020).

### ***Examining the TIP principles using the CA***

As previously elucidated in Section 3, our conceptualization of directionality encompasses a principle logic that fosters possibilities for innovation with direction(s) and facilitates navigating multiple directions of innovations. In this way, it addresses power imbalances and privileges while simultaneously mapping out diverse directions for system change through alternative solutions. In this context, we analyze how the components of the CA approach enhance and reinforce the directionality of TIP.

Regarding the *Societal Goals* principle, the CA adds a normative dimension to the identification of societal goals and provides a framework to assess well-being by emphasizing the importance of expanding people's capabilities and agency and removing unfreedoms as a societal goal in itself. This can help ensure that societal goals are not just about addressing, for example, climate change but also about creating further favorable conditions for transformative change.

At the system level principle, the CA offers valuable insights for assessing the agency of actors and organizations involved in TIP initiatives, particularly in their efforts to alter entrenched regime rules across the various dimensions of a socio-technical system, including culture, policy, industry, markets, science and technology. By incorporating personal, social, and environmental conversion factors into the analysis, the CA helps evaluate the extent to which various groups can – or cannot – participate in TIP policy processes. This, in turn, influences the design and effectiveness of interventions and the capacity of individuals, groups, networks and organizations to enact meaningful change within complex systems. The CA poses central questions about how, whose, and what type of knowledge is recognized in the science and technology dimension.

More specifically, we see opportunities in which the CA can strengthen systems analysis in each dimension. In the policy dimension, the CA adds a normative layer on well-being, capability expansion, and empowerment of communities through participatory processes within the entire policy cycle. In the industry dimension, the CA emphasizes deliberation processes for defining standards, protocols, and surveillance of finances.

In the users and markets dimension, the CA can be seen from the users' agency, for example, users becoming producers. Also, the CA can raise questions about who benefits from market arrangements, how those benefits are distributed, or if the market is enhancing people's opportunities. In culture, the CA highlights what is valued by different communities.

Concerning learning and reflexivity, the CA recognizes the importance of learning as part of democratic decision-making in enhancing people's capabilities and empowering them to participate in the innovation process meaningfully. The CA emphasizes the importance of reflexivity in fostering human development through the epistemic justice capability, as it enables individuals to make more informed choices and engage more effectively with others. These are normative arguments for implementing participatory methodologies to enhance learning and reflexivity in TIP experimentation.

Finally, the new democratic decision-making principle, grounded in human development values, emphasizes the democratization of innovation by ensuring access, participation, and the recognition of diverse voices in the process. It also aims to remove the unfreedoms faced by vulnerable groups. This approach reveals potential tensions and trade-offs, fosters awareness of stakes and stakeholders, and offers tools for addressing conflict and managing power dynamics. Doing so ensures that innovation outcomes are inclusive and responsive to the needs and aspirations of all individuals and communities, and it enhances the agency of marginalized groups. Table 1 summarizes the contributions of the CA to the TIP principles:

**Table 1.** Contribution of the CA to the TIP principles.

Principle	Description	Contribution of CA
0. Embracing Directionality (guiding principle)	Grasping irreducible pluralities of possibility in balanced ways	Aligned to the CA approach of addressing power imbalances and privileges
1. Orienting towards societal goals	Research and innovation incorporating ethical, social, and environmental considerations into assessing new technologies for diverse societal goals (e.g 17 SDGs), instead of one way forward and recognizing non-neutrality of technologies	In emphasizing the importance of expanding people's capabilities and agency and removing unfreedoms as a societal goal in itself; ensuring that Societal Goals are not just about addressing climate change, but about creating further favorable conditions for transformative change.
2. Adopting a systemic perspective	A comprehensive socio-technical understanding of the intricate interplay of science and technology, markets and users, industry and finance, policy and governance, and cultural dimensions	In assessing the agency of actors and organizations in each dimension, by incorporating personal, social, and environmental conversion factors into the analysis
3. Learning and reflexivity	A practise of challenging established mental frameworks, bodies of knowledge, routines, beliefs, and practices across diverse stakeholder groups, including varieties and pluralities of processes of learning and reflecting on one's assumptions	In recognizing epistemic justice capability as central to human development for making informed choices and engaging more effectively with others, by putting in practice participatory methodologies
4. Democratic decision making	Deliberative and participatory processes for plurality of perspectives, avoiding misrepresentations and other forms of hidden injustices; incorporating conflict, consensus, inclusivity and empowerment of alternatives developed by non-dominant actors, enhancing justice of all forms	In focussing on removing unfreedoms faced by vulnerable groups, recognition of diverse voices, addressing conflict, gaining awareness of stakes and stakeholders through managing power relations

Source: Own elaboration.

## **A practical example of how the CA can enhance the justice dimension of a TIP policy engagement**

This section provides a practical example of how a TIP experimental policy engagement can benefit from the CA. Within the TIPC methodology, Experimental Policy Engagements (EPEs) function as action research initiatives, fostering collaboration among policymakers, researchers, and various stakeholders. Their primary goal is to leverage systemic change towards a more desirable future. As ‘experimental’ efforts, EPEs acknowledge that there is no one-size-fits-all solution for addressing complex challenges, which are characterized by uncertainties, diverse interests, and the integration of both expert and non-expert knowledge. This dynamic environment requires continuous collaboration, coordination, and negotiation.

This example is drawn from a real EPE conducted by researchers, students, policymakers, and practitioners from TIPC, in collaboration with the South African Department of Science and Innovation, the South African Water Research Commission, the South African National Biodiversity Institute, the University of Johannesburg, and other national institutions. The EPE aimed to strengthen the transformative potential of the ‘Living Catchments’ (LC) project, part of South Africa’s 2015–2025 Water Research, Development, and Innovation Roadmap – a national initiative designed to address the critical issue of water scarcity in the country.

The societal goal was to transform water governance as South Africa faces multiple urgent water challenges, including supply insecurity, ecological infrastructure degradation, inadequate landscape governance, and resource pollution. These issues are further compounded by aging infrastructure, rapid population growth, and the effects of climate change (Department of Water and Sanitation 2018). The primary focus of the LC Project was to strengthen water governance by fostering communities of practice that unite local communities, researchers, water practitioners, and national and local policymakers. The engagement occurred during the COVID-19 pandemic through digital workshops for 16 weeks. This collaborative approach strengthened water security by integrating built and ecological infrastructure. This example is chosen to represent a typical TIPC engagement, though the interpretation and analysis are the authors’ sole responsibility.<sup>7</sup>

From the outset, the LC project prioritized the inclusion of diverse stakeholders in key water catchment areas by creating social spaces that facilitated collective agenda-setting processes. These efforts aimed to enhance water security through the optimal use of both ecological and built infrastructure. Applying a CA to the experimental engagement would have introduced additional considerations related to justice, such as how the well-being of surrounding communities was addressed, what they value in terms of water availability and use, how new infrastructures alter their landscape, and an explicit focus on both collective and individual capabilities.

Incorporating a capability perspective on agency and the democratic decision-making principle could have significantly enriched the procedure to nurture the communities of practice as part of the intended water governance structure. This approach would have introduced critical reflections and, potentially, contestations regarding the concept of collaboration. Emphasizing the development of team agency and equipping catchment communities of practice with tools to address power imbalances and promote democratic

deliberation within LC activities would have enriched learning and epistemic capabilities and fostered skills related to collaboration and teamwork. Participation would have been seen as a practical tool, a fundamental principle, and a political stance. Moreover, the normative framework provided by the CA could have sparked essential discussions on the meanings and contested interpretations of sustainability, justice, and solidarity – topics that were notably absent throughout the sessions.

The LC project aimed to establish communities of practice with strong local representation, alongside the involvement of social scientists and decision-makers in the agenda-setting process. However, the LC experimental engagement with TIPC researchers involved only a limited group of actors, excluding local community representatives, field facilitators, and technical personnel. While this was acknowledged as a shortcoming in the engagement design, particularly due to the shift to a digital setting during the pandemic, a more democratic approach would have prioritized broader access, participation, and the recognition of diverse voices. Additionally, a capabilities perspective would have highlighted concerns of epistemic justice, ensuring that less privileged voices were included in both the design and implementation of the experiment, while also fostering the conditions necessary for meaningful participation.

Additionally, the LC project did not account for personal conversion factors, which are essential for fostering inclusion and meaningful engagement. Analyzing these factors would have provided valuable insights into participants' characteristics – such as values, motivations, expectations, political affiliations, and emotional factors – crucial for engaging marginalized voices on their own terms. Tools and languages tailored to their needs would have enabled more effective policy engagement. The EPE could have begun by identifying and analyzing both individual and collective conversion factors within the catchment communities of practice, to better convert their capabilities into real-world outcomes.

Finally, a more comprehensive examination of social conversion factors could have offered a deeper contextual understanding of the experiment and its socio-technical system, particularly regarding water provision. The CA would have encouraged a more profound exploration of the political context, gender relations, and other social norms, enriching discussions and reflections, broadening perspectives on directionality, and enhancing the potential for systemic change.

## Conclusions

This paper explored how the CA can deepen the justice perspective within TIP, particularly as developed by the TIPC. Our analysis centered on reinterpreting the directionality principle of TIP, adopting a more politically conscious perspective that views directionality as an irreducible plurality of possibilities in balanced ways (Stirling 2024). This shift prompted us to reconsider the original TIP principles, emphasizing the democratic dimension of innovation. Consequently, we proposed a new principle – democratic decision-making – that replaces the former principles of inclusivity and conflict versus consensus. While valuable, the previous principles insufficiently addressed the need to empower alternative innovation practices led by non-dominant actors and challenge the prevailing unfair and unsustainable practices (Avelino, Monticelli, and Wittmayer 2019). We argue that fostering deeper democratic processes is crucial for TIP and

innovation more broadly, as it facilitates continuous reflection and improvement in collective decision-making at both local and global levels. Together with the new principle of democratic decision-making, we have kept three original principles of TIP: societal goals, system change, and learning and reflexivity.

We then examined the core elements of the CA to explore how they can inform the four principles of TIP. Our analysis revealed that the concepts of capability, agency, and conversion factors can add valuable normative considerations to the core elements of TIP. We also extended this analysis to deepen the practice of the TIP principles. Specifically, we argued that the notion of a societal goal, which is central to TIP, could be enriched by incorporating the CA's focus on removing 'unfreedoms' and creating favorable conditions for transformation. This perspective on societal goals aligns with and can be applied to other innovation processes, as suggested by various scholars within the capability framework (Capriati 2022; Chiappero-Martinetti, Houghton Budd, and Ziegler 2017; Ziegler, Karanja, and Dietsche 2013). This approach broadens the scope of TIP, emphasizing not only the pursuit of innovation but also the creation of conditions that enhance human freedom and well-being.

The second principle, systemic change, is a core aspect of TIP, and we have argued how the CA can enrich the analysis of the five dimensions of socio-technical systems (culture, regulations, industry market, science, technology). We argue that this systemic approach can also be useful for other innovation perspectives and for the CA community itself. It offers a more comprehensive understanding of what must be transformed to reach a just transition. Conversely, the CA strengthens the justice dimension of this transformation by integrating considerations of capability, agency, and conversion factors, as discussed in our earlier analysis (Boni, Velasco, and Tau 2021; Velasco et al. 2021; Velasco, Boni, and Chalela 2021).

The third principle, learning and reflexivity, is enhanced by reinforcing the justice dimension as developed by the CA, stressing the importance of the epistemic capability as a way to promote meaningful participation in the innovation processes. Conversely, the CA can be reinforced with the approach to learning, which implies changes in beliefs, values, behaviors, and assumptions that shape individual and collective understanding and action towards social and environmental challenges. This 'second-order learning capability' can be expanded in innovation processes and can reinforce the expansion of other capabilities for transformative change.

Finally, the new democratic decision-making principle has been bolstered by the Capability Approach (CA), which underscores the importance of agency – the ability of marginalized groups to effect change. Additionally, the CA aids policymakers in evaluating the personal, social, and environmental conversion factors that impact individuals' capabilities and address the unfreedoms that restrict their participation in innovation processes. By identifying and removing these barriers, the CA supports more inclusive and effective engagement in decision-making.

We argue that TIP, as an approach aiming for fundamental societal transformations through socio-technical innovations, can be strengthened by understanding and enhancing capabilities, fostering a fertile dialogue with the CA. This dialogue can benefit the directionalities of innovation, addressing failures and reorienting it towards sustainable and equitable transformation pathways. This enriched perspective supports the development of TIP as a robust framework for driving systemic, just, and inclusive innovation.

## Notes

1. In this paper, we refer to policy as encompassing a broad range of initiatives, including projects, programs, and overarching policies that can integrate different initiatives. The concept of policy in the context of TIP discussed here becomes experimental, as it involves time-bound efforts to foster transformation through a reflexive and learning-oriented approach (Molas-Gallart et al. 2021).
2. With some exceptions: see (Nussbaum 2006) and the theory of disadvantage by (Wolff and De-Shalit 2007) for a comprehensive theory of justice based on the CA. To understand the CA as a non-ideal theory of justice relevant to innovation policy, see (Papaioannou 2021).
3. The Transformative Innovation Policy Consortium (TIPC) is a multi-country initiative (started in 2016) dedicated to fostering TIP. Its goal is leveraging science, technology, and innovation to achieve socio-technical system change and a sustainable future. TIPC brings together policymakers, researchers, investors, and funders with the aim to: 1) Develop a new narrative for STI policy – one that prioritizes achieving the Sustainable Development Goals over merely maximizing economic growth; 2) Build demonstrators through experiments that illustrate how to approach, implement, and evaluate TIP and 3) Generate a global community of practice that applies and enhances TIP and its principles. TIPC members and partners co-create a work program that includes experimentation, research, training, and capability building. This work is supported by Hubs, open-access resources in the TIP Resource Lab, and a thriving global Knowledge Community (<https://tipconsortium.net/about-tipc/>).
4. See, as an example, this learning material produced in 2019: Schepers and Steinmueller (2019) A Transformative Innovation Learning Journey. Available at <https://www.tipconsortium.net/resource/a-transformative-innovation-learning-journey/>. Also, see the web page of the Catalonia Government, one of the associate members of TIPC: <https://fonseuropeus.gencat.cat/ca/ris3cat/2030/agendes-compartides/>. It includes a video recording to explain the key characteristics of TIP in which the 6 principles are extensively presented. This video can be retrieved at <https://media.upv.es/#/portal/video/2a2b07e0-4629-11ed-a617-9fb64b581fd2>
5. This tool can be retrieved at <https://tipresourcelab.net/resource/tool-transformative-innovation-policy-radar/>
6. For scholars that have advocated for collective capabilities, see Stewart (2005) and Ibrahim (2006).
7. For a detailed description of the engagement, see (Boni, Velasco, and Tau 2021; Magada et al. 2023)

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